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(54) **WIRELESS POWERED HOUSE**

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CPC ***H02J 7/025*** (2013.01); ***H02J 5/005*** (2013.01); ***H02J 7/35*** (2013.01); ***H02J 17/00*** (2013.01)

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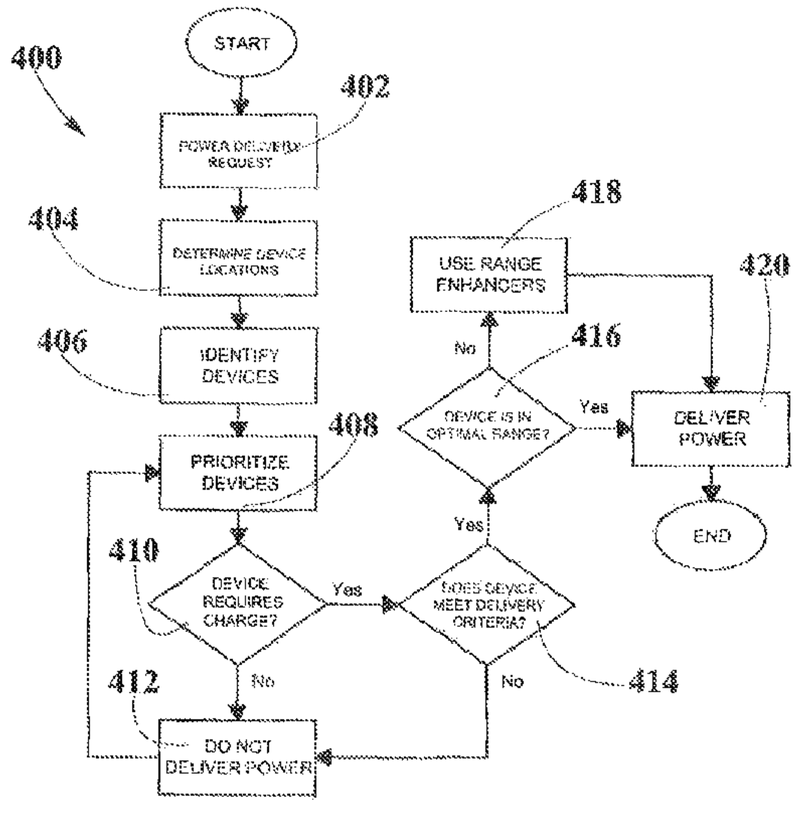
(57) **ABSTRACT**

The present disclosure may provide a wireless power system which may be used to provide wireless power transmission while using pocket-forming. The wireless power system may be used in a house for providing power and charge to a plurality of mobile and non-mobile devices. The house may include a single base station that may be connected to several transmitters. The base station may manage operation of every transmitter in an independently manner or may operate them as a single transmitter. The connection between the base station and transmitters may be achieved through a plurality of techniques including wired connections and wireless connections. The base station may include at least one micro-controller and a power source.

19 Claims, 4 Drawing Sheets



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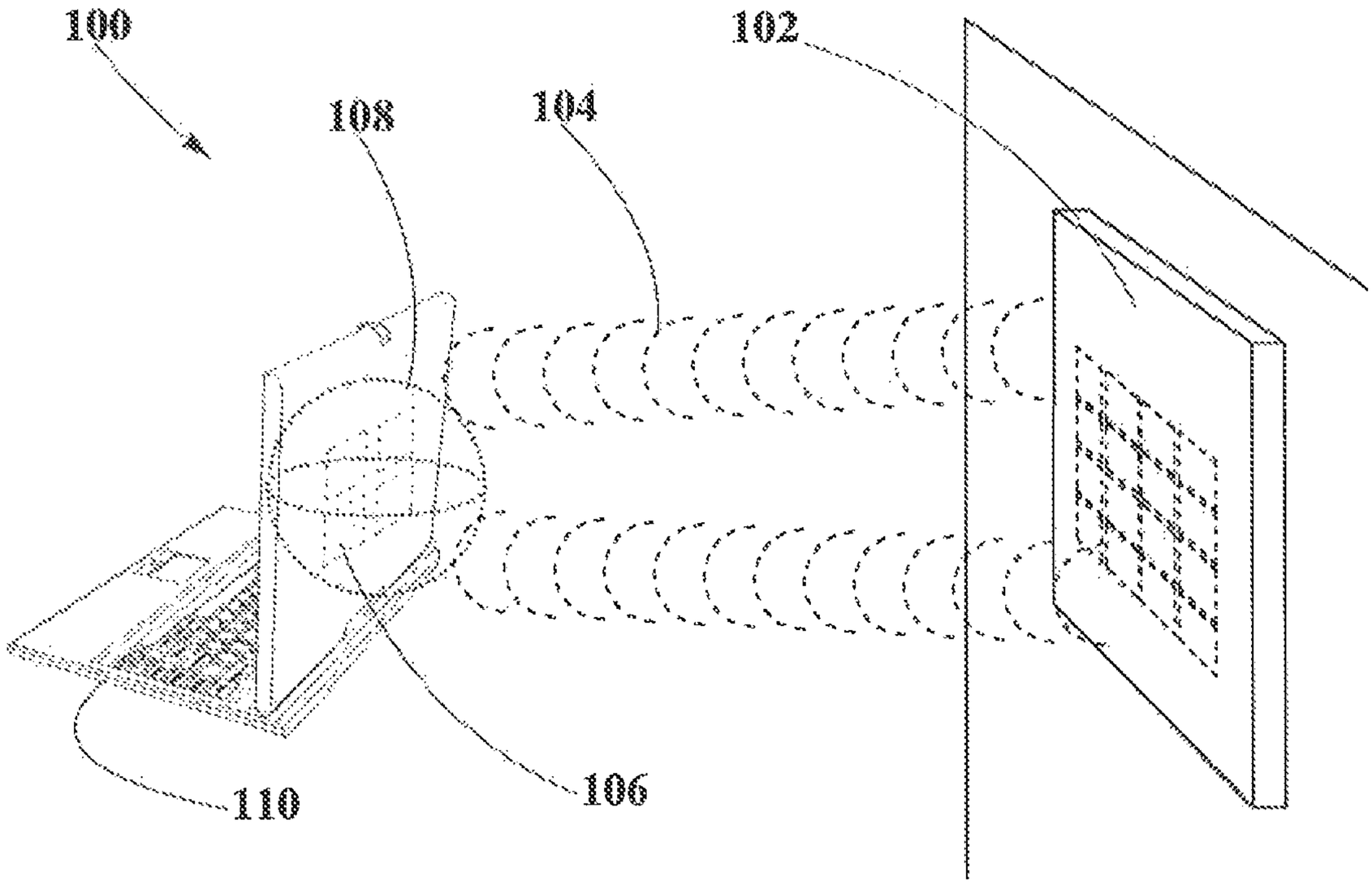

FIG. 1

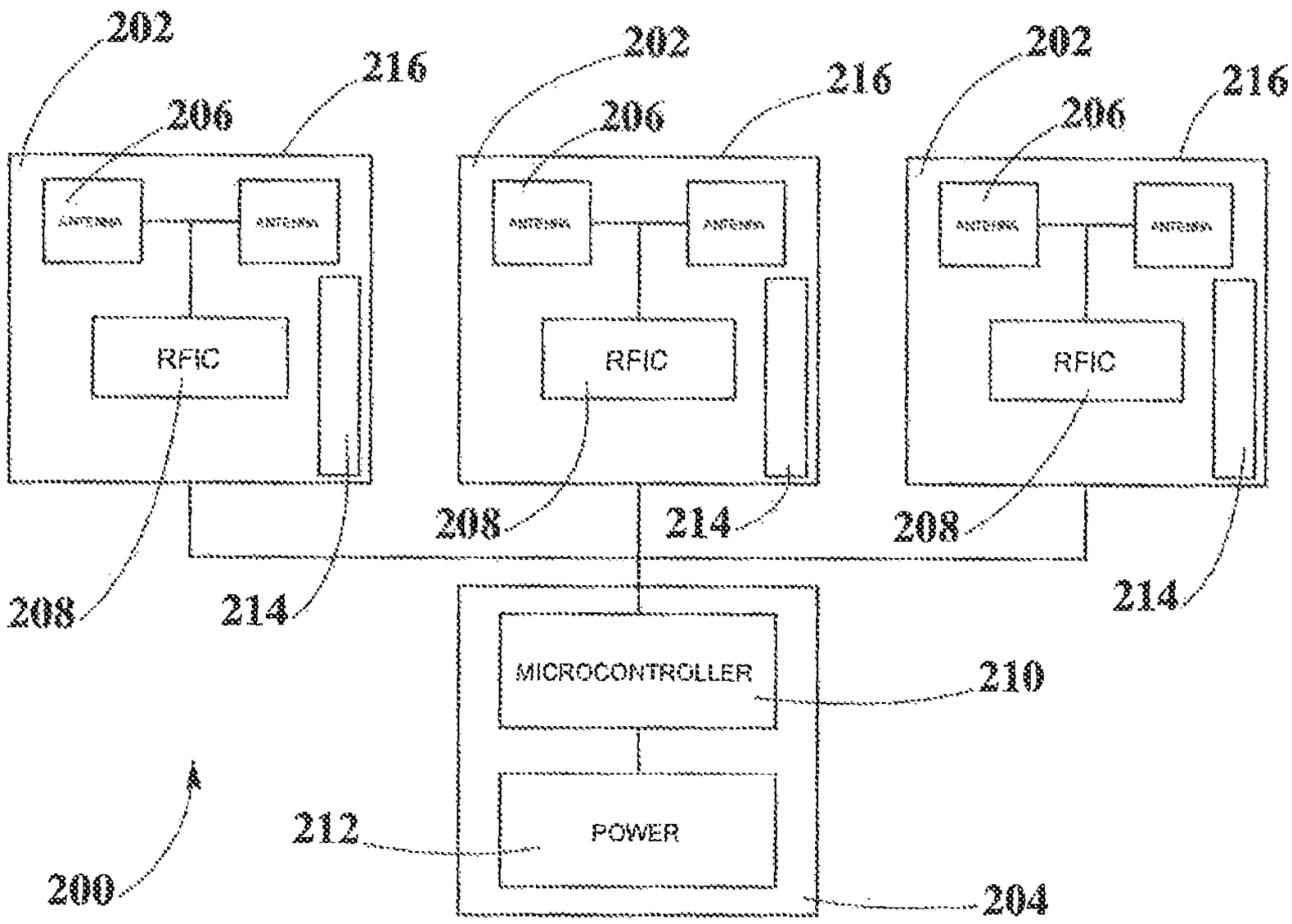
202
206
216
ANTENNA
ANTENNA
RFIC
208
214
MICROCONTROLLER
210
POWER
212
200
204

FIG. 2

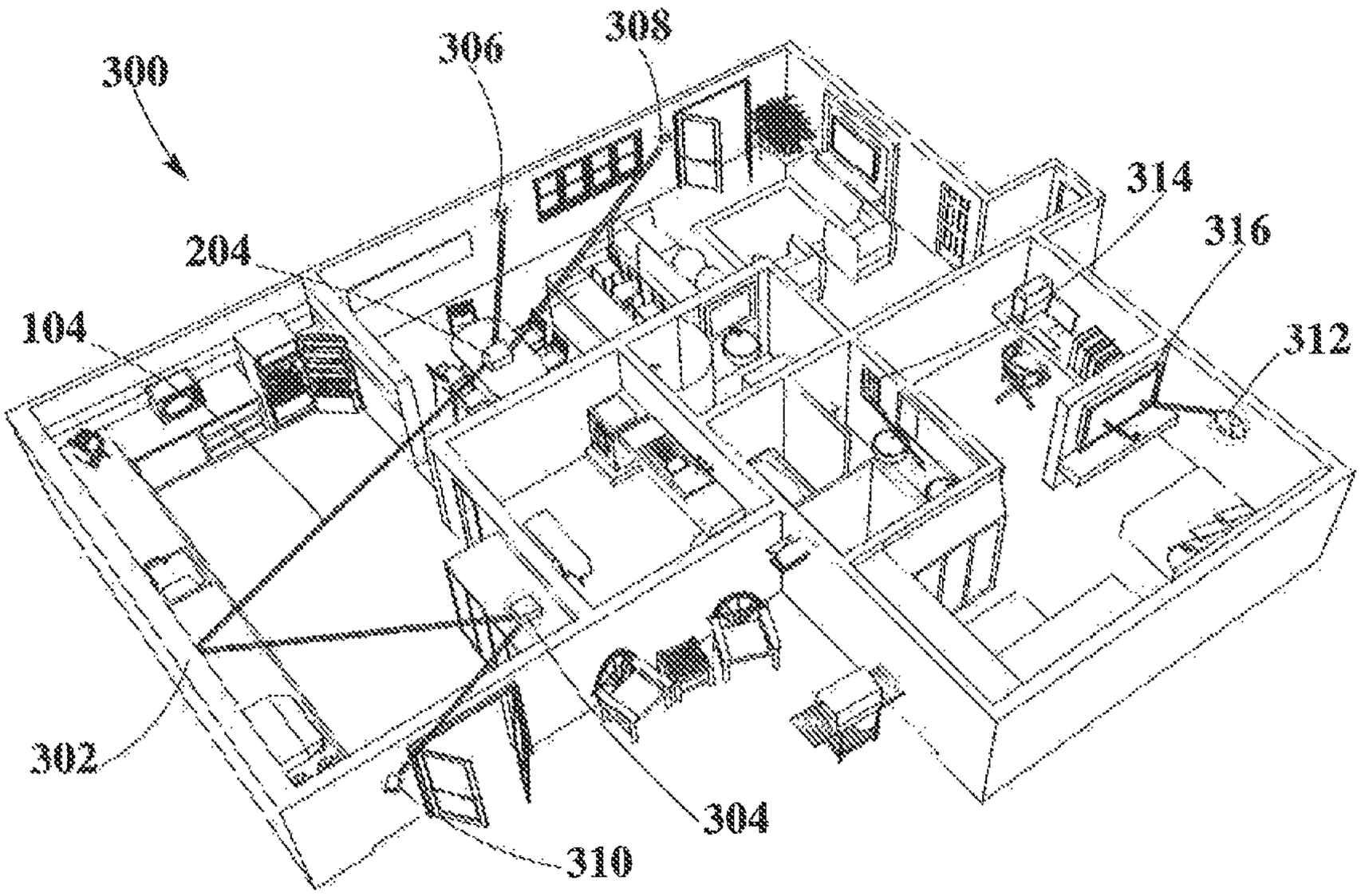

FIG. 3

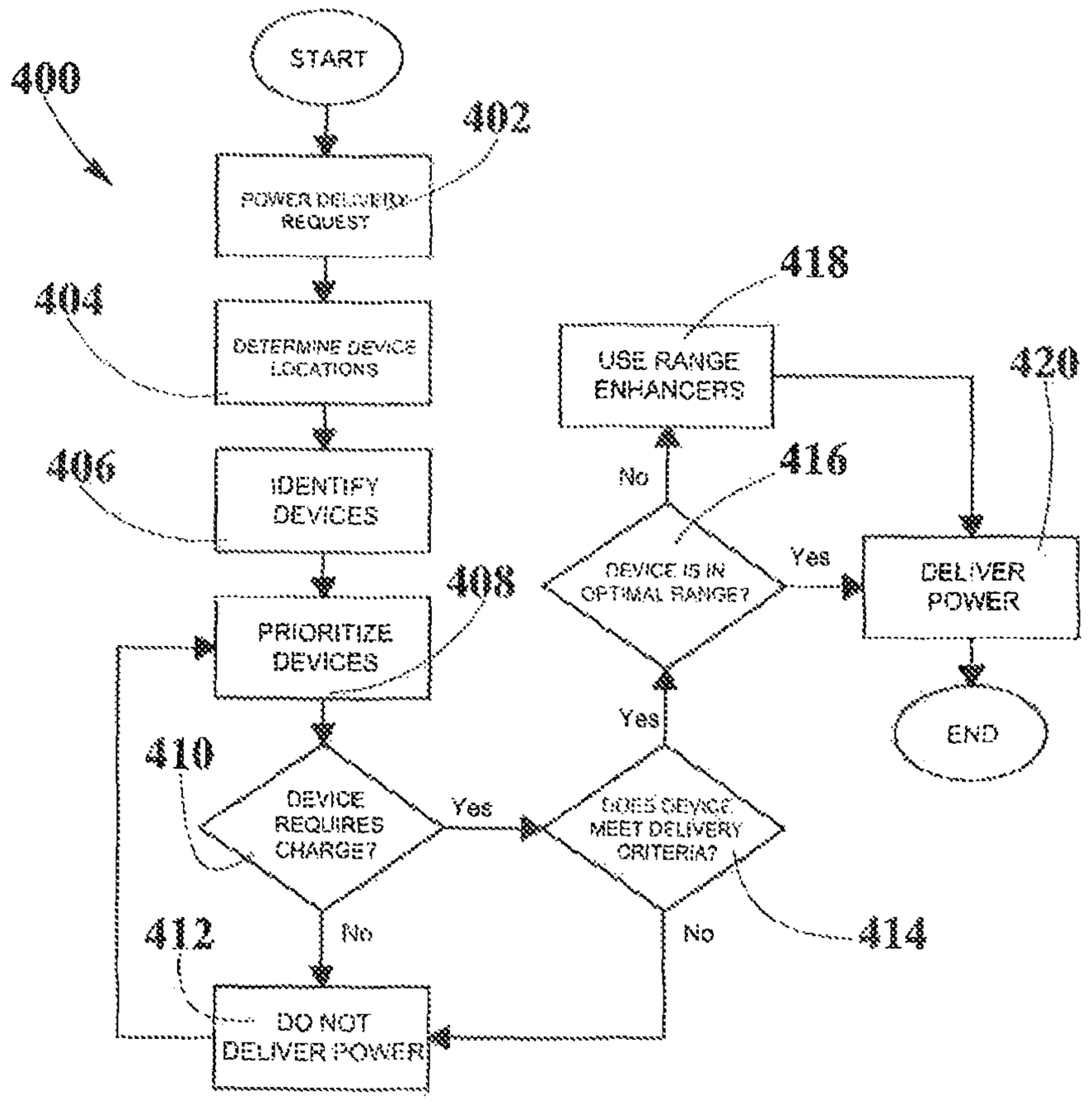
400
START
402
POWER DELIVERY REQUEST
404
DETERMINE DEVICE LOCATIONS
406
IDENTIFY DEVICES
408
PRIORITIZE DEVICES
410
DEVICE REQUIRES CHARGE?
Yes
No
412
DO NOT DELIVER POWER
DOES DEVICE MEET DELIVERY CRITERIA?
Yes
No
414
DEVICE IS IN OPTIMAL RANGE?
416
Yes
No
418
USE RANGE ENHANCERS
420
DELIVER POWER
END

Fig. 4

WIRELESS POWERED HOUSE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 14/069,983, filed on Nov. 1, 2013, which is incorporated by reference in its entirety.

This application relates to U.S. Non-Provisional patent application Ser. No. 13/891,430 filed May 10, 2013, entitled "Methodology For Pocket-forming;" U.S. Non-Provisional patent application Ser. No. 13/891,445 filed May 10, 2013, entitled "Transmitters for Wireless Power Transmission;" U.S. Non-Provisional patent application Ser. No. 13/946,065 filed on Jul. 19, 2013, entitled "Home Base Station for Multiple Room Coverage with Multiple Transmitters;" U.S. Non-Provisional patent application Ser. No. 13/939,506, filed Jul. 11, 2013, entitled "Wireless Tracking Pocket Forming;" U.S. Non-Provisional patent application Ser. No. 13/926,020, filed Jun. 25, 2013, entitled "Wireless Power Transmission with Selective Range;" U.S. Non-Provisional patent application Ser. No. 13/916,233, filed Jun. 12, 2013, entitled "Wireless Charging with Reflectors;" U.S. Non-Provisional patent application Ser. No. 13/925,469 filed Jun. 24, 2013, entitled "Methodology for Multiple Pocket-Forming;" U.S. Non-Provisional patent application Ser. No. 14/583,625, filed Dec. 27, 2014, entitled "Receivers for Wireless Power Transmission," U.S. Non-Provisional patent application Ser. No. 14/583,630, filed Dec. 27, 2014, entitled "Methodology for Pocket-Forming," U.S. Non-Provisional patent application Ser. No. 14/583,634, filed Dec. 27, 2014, entitled "Transmitters for Wireless Power Transmission," U.S. Non-Provisional patent application Ser. No. 14/583,640, filed Dec. 27, 2014, entitled "Methodology for Multiple Pocket-Forming," U.S. Non-Provisional patent application Ser. No. 14/583,641, filed Dec. 27, 2014, entitled "Wireless Power Transmission with Selective Range," and U.S. Non-Provisional patent application Ser. No. 14/583,643, filed Dec. 27, 2014, entitled "Method for 3 Dimensional Pocket-Forming," all of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present disclosure relates to wireless power transmission, and more particularly to wireless powered house using a plurality of techniques and technologies for wireless power transmission.

BACKGROUND

Electronic devices such as laptop computers, smartphones, portable gaming devices, tablets and so forth may require power for performing their intended functions. This may require having to charge electronic equipment at least once a day, or in high-demand electronic devices more than once a day. Such an activity may be tedious and may represent a burden to users. For example, a user may be required to carry chargers in case his electronic equipment is lacking power. In addition, users have to find available power sources to connect to. Lastly, users must plugin to a wall or other power supply to be able to charge his or her electronic device. However, such an activity may render electronic devices inoperable during charging. In addition, cables infrastructure may include drilling on walls and conduit installation, which increase maintenance cost and may be non-esthetic.

In addition, some electronic devices may require restricted use in certain areas of the house, thus safety may be increased for children. Such devices may include: drillers, electric knives among others. Current technology allows these devices to operate in any electric plug.

Current solutions to these problems may include inductive pads which may employ magnetic induction or resonating coils. Nevertheless, such a solution may still require that electronic devices may have to be placed in a specific place for powering. Thus, electronic devices during charging may not be portable.

For the foregoing reasons, there is a need for a wireless power transmission system where electronic devices may be powered without requiring extra chargers or plugs, and where the mobility and portability of electronic devices may not be compromised.

SUMMARY

The present disclosure provides a plurality of wireless transmitters which can be utilized for wireless power transmission using suitable techniques such as pocket-forming. Such transmitters may be installed for charging and powering mobile and non-mobile devices in a house. Transmitters may be employed for sending Radio frequency (RF) signals to electronic devices which may incorporate receivers. Such receivers may convert RF signals into suitable electricity for powering and charging a plurality of electric devices. Wireless power transmission allows powering and charging a plurality of electrical devices without wires.

Wireless power system may include several transmitters located in different locations for enabling multiple room coverage. In order to improve this feature, a single base station may manage each transmitter in different location with different and independent operation modes. Furthermore, base stations may enable the use of all transmitters as a single transmitter.

Base stations may reduce the cost of a wireless power system, because specific circuitry may only be placed in base stations rather than on each transmitter. In addition, the use of a base station for controlling several transmitters may improve the managing and charging of several receivers.

Base station may use a CPU, computer, micro-controller among others components for processing information from receivers and transmitters. Furthermore, a variety of protocol may be executed by base station in order to charge and power a plurality of mobile and non-mobile devices, such protocols may include priorities, restricted locations, and authentication among others. Protocols may be customized by the user.

Numerous other aspects, features and benefits of the present disclosure may be made apparent from the following detailed description taken together with the drawings provided.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure can be better understood by referring to the following figures. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the disclosure. In the figures, reference numerals designate corresponding parts throughout the different views.

FIG. **1** illustrates a wireless power transmission example situation using pocket-forming.

FIG. **2** illustrates a component level embodiment for a wireless power system including three transmitters.

FIG. **3** illustrates a wireless powered house with a variety of transmitters and receivers.

FIG. **4** illustrates an example routine that may be utilized by a micro-controller from base station (as described in FIG. **2**) to deliver power to receivers which may require wireless power transmission, according to an embodiment.

DETAILED DESCRIPTION

Definitions

"Pocket-forming" may refer to generating two or more RF waves which converge in 3-d space, forming controlled constructive and destructive interference patterns.

"Pockets of energy" may refer to areas or regions of space where energy or power may accumulate in the form of constructive interference patterns of RF waves.

"Null-space" may refer to areas or regions of space where pockets of energy do not form because of destructive interference patterns of RF waves.

"Transmitter" may refer to a device, including a chip which may generate two or more RF signals, at least one RF signal being phase shifted and gain adjusted with respect to other RF signals, substantially all of which pass through one or more RF antenna such that focused RF signals are directed to a target.

"Receiver" may refer to a device including at least one antenna element, at least one rectifying circuit and at least one power converter, which may utilize pockets of energy for powering, or charging an electronic device.

"Adaptive pocket-forming" may refer to dynamically adjusting pocket-forming to regulate power on one or more targeted receivers.

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, which are not to scale or to proportion, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings and claims, are not meant to be limiting. Other embodiments may be used and/or and other changes may be made without departing from the spirit or scope of the present disclosure.

FIG. **1** illustrates wireless power transmission **100** using pocket-forming. A transmitter **102** may transmit controlled Radio RF waves **104** which may converge in 3-d space. These radio frequencies (RF) waves **104** may be controlled through phase and/or relative amplitude adjustments to form constructive and destructive interference patterns (pocket-forming). Pockets of energy **108** may be formed at constructive interference patterns and can be 3-dimensional in shape whereas null-spaces may be generated at destructive interference patterns. A receiver **106** may then utilize pockets of energy **108** produced by pocket-forming for charging or powering an electronic device, for example a laptop computer **110** and thus effectively providing wireless power transmission **100**. In other situations there can be multiple transmitters **102** and/or multiple receivers **106** for powering various electronic equipment, for example smartphones, tablets, music players, toys and others at the same time. In other embodiments, adaptive pocket-forming may be used to regulate power on electronic devices.

FIG. **2** depicts a block diagram of a wireless power system **200**, which may include a plurality of wireless power transmitter **202** connected to a single base station **204**. Transmitters **202** may include one or more antenna elements **206**, one or more Radio frequency integrated circuit (RFIC) **208**, a communication component **214** and a housing **216**, which may allocate all the components previously mentioned. Base station **204** may include one or more micro-controller **210**, a power source **212** and a housing **216**, which may allocate all the components previously mentioned. Components in wireless power system **200** and base station **204** may be manufactured using meta-materials, micro-printing of circuits, nano-materials, and the like.

Base station **204** may be located in variety of locations where transmitters **202** can stay connected to it. Such connection may include a variety of connections, which may include coaxial cable, phone cable, LAN cable, wireless connection among others. The connection between base station **204** and transmitters **202** aims to establish a link between RFIC **208** and micro-controller **210**, as well as the power source **212** connection.

Micro-controller **210** may control a variety of features of RFIC **208** such as, time emission of pocket-forming, direction of the pocket-forming, bounce angle, power intensity and the like. Furthermore, micro-controller **210** may control multiple pocket-forming over multiple receivers **106** or over a single receiver **106**. In addition, micro-controller **210** may manage and control communication protocols and signals by controlling communication component **214**. Thus micro-controller **210** may drive the foregoing features in several transmitters **202** at the same time.

Base station **204** may be fed by a power source **212** which in turn may feed to transmitters **202**. Power source **212** may include AC or DC power supply. Voltage, power and current intensity provided by power source **212** may vary in dependency with the required power to be transmitted. Conversion of power to radio signal may be managed by micro-controller **210** and carried out by RFIC **208**, which may utilize a plurality of methods and components to produce radio signals in a wide variety of frequencies, wavelength, intensities and other features. As an exemplary use of a variety of methods and components for radio signal generation, oscillators and piezoelectric crystals may be used to create and change radio frequencies in different antenna elements **206**. In addition, a variety of filters may be used for smoothing signals as well as amplifiers for increasing power to be transmitted.

Base station **204** may enable operation of different transmitters **202** in different rooms and/or areas coverage. Each transmitter **202** may operate at different frequencies, power intensities and different ranges. In addition, each transmitter **202** may provide power to a plurality of receivers **106**. Furthermore, base station **204** may enable a single operation of all transmitter **202**, thus may provide a higher capability for wireless charging by the use of each transmitter **202** as a single one.

FIG. **3** depicts a wireless powered house **300**, which may include a plurality of transmitters **202** connected to a single base station **204**, which may also include a main transmitter **202**. Base station **204** allows the charge management of mobile and non-mobile devices in wireless powered house **300**. Additionally, transmitters **202** may be embedded into a plurality of electronic devices and objects in wireless powered house **300**.

Base station **204** may enable communication between every transmitter **202** and receiver **106** in wireless powered house **300**, as described in FIG. **2**. Furthermore, wireless powered house **300** may include a variety of range enhancers, which may increase range of wireless power transmission **100**, such range enhancers may include: reflectors **302** and wireless repeaters **304**. Reflectors **302** may be included in several places of the wireless powered house **300**, such as curtains, walls, floor, and ceiling among others. Wireless

repeaters **304** may include a receiver **106** and a transmitter **202** for re-transmitting power. FIG. **3** illustrates an example for using reflectors **302** and wireless repeaters **304**, where a CCTV camera **310** requires charge, but it is too far for receiving power at an optimal efficiency. However, base station **204** may trace a trajectory for RF waves **104** which may imply less loses and includes the use of reflectors **302** that may be embedded in the walls and a wireless repeater **304**, which may receive the reflected RF waves **104** and re-transmits these to the CCTV camera **310** with higher power than the received.

As depicted in FIG. **3**, base station **204** may send RF waves **104** to any device in wireless powered house **300**, these devices may include static devices such as: Smoke detectors **306**, digital door locks **308**, CCTV cameras **310**, wall clocks **312** among others devices that requires wired powered connections. The lack of cables for powering such devices may reduce work time for installing and maintaining those devices. Furthermore, walls, ceilings and floors may not require to be drilled for installing cables.

Device locations may be updated automatically by base station **204**, which may set a communication channel between each device, regardless if it is a mobile or non-mobile device.

Some devices such as mirrors **314** may allow a transmitter **202** in order to charge small devices and disposable devices in the bathroom and/or in the bedroom. Such devices may include: Electric razors, electric toothbrushes, lamps, massagers, UV-Sterilizers among others. Therefore, mirror **314** may significantly reduce wired chargers for each electric device in bathrooms and bedrooms.

Similarly to mirror **314**, televisions **316** may include transmitters **202** powering and charging mobile and non-mobile devices.

Base station **204** may establish areas where wireless power transmission **100** may have specialized protocols, these areas may include infirmary, children rooms, room for pregnant and other regions where some devices may be sensitive to RF waves **104**. Some areas may represent a permanent null space, where no pockets of energy **108** are generated. Furthermore, some receivers **106** may possess the same specialized protocols regardless their location in wireless powered house **300**. Such devices may include electric knives, drills, and lighters among others. Therefore, each device may be restricted to a specific area and to a specific user, thus, safety in wireless powered house **300** may be higher than in conventional powered houses. Hence, children may not be to use harmful hardware and thieves may not be able to use stolen equipment outside the wireless powered house **300**.

FIG. **4** illustrates an example routine **400** that may be utilized by micro-controller **210** from base station **204** in wireless powered house **300** to control wireless power transmission **100**. Routine **400** may begin when any transmitter **102** in wireless powered house **300** receives a power delivery request Step **402** from receiver **106**. Subsequently, at determine device locations Step **404**, a receiver **106** may send a signal via Bluetooth, RF waves **104**, infrared among others to the closest transmitter **102**. Then, transmitter **202** may determine location of receiver **106** in wireless powered house **300**. After this procedure, at identify devices Step **406** receiver **106** may send a signature signal to the closest transmitter **102**, such signal may be coded using suitable techniques such as delay encoding, orthogonal frequency-division multiplexing (OFDM), code division multiplexing (CDM) or other suitable binary coding for identifying a given electronic device including receiver **106**. At this step, micro-controller **210** may obtain information from receiver **106** such as type of device, manufacturer, serial number, total power required. Then, micro-controller **210** in base station **204** may proceed to authenticate where it may evaluate the signature signal sent by receiver **106**. Micro-controller **210** may proceed to a decision. If receiver **106** is not authorized to receive power, micro-controller **210** may decide to block it. If receiver **106** is authorized, it may receive charge based on his assigned priority, such value is determined at prioritize devices Step **408**, such value may be set by the user preferences and charge level of the equipment, such charge level may be determined in device requires charge? Step **410**. If the device does not requires charge, transmitter **102** may not charge it at do not deliver power Step **412**. Furthermore, such device may be listed as low priority to charge during prioritize devices Step **408**.

In addition, if multiple receivers **106** are requiring power, micro-controller **210** may deliver power equally to all receivers **106** or may utilize a priority status for each receiver **106**. In some embodiments, the user may choose to deliver more power to its smartphone, than to its gaming device. In other cases, the user may decide to first power its smartphone and then its gaming device. Furthermore Smoke detectors **306**, digital door locks **308** and CCTV cameras **310** among others similar devices, may have the highest priority.

When the receiver **106** is authorized to receive charge, it has to meet some criteria at does device meet delivery criteria? Step **414**. The foregoing powering criteria may depend on the electronic device requiring power and/or based in user preferences. For example, smartphones may only receive power if are not being used, or maybe during usage but only if the user is not talking through it or maybe during usage as long as Wi-Fi is not compromised among other such criteria. In the case of a user custom profile, the user may specify the minimum battery level its equipment can have before delivering power, or the user may specify the criteria for powering his or her device among other such options. In addition, in wireless powered house **300**, some devices may possess some special criteria, as described in FIG. **3**; such devices may be required to operate in specific rooms. Such devices may include drillers, electric knives, lighters, electric screwdrivers, saws, among others. Furthermore, some devices may require some user authentication, which may be achieved through password verification or biometric authentication. These two criteria may be used in combination for a maximum level of safety. Such combination may generate a single criterion related to parental control protocol, which may also include manage of power intensity for toys and operation areas for them.

Alternatively, micro-controller **210** may also record data on a processor on transmitter **102**. Such data may include powering statistics related to how often does a device require power, at what times is the device requesting power, how long it takes to power the device, how much power was delivered to such device, the priority status of devices, where is the device mostly being powered (for example at home or in the workplace). In addition, such statistics could be uploaded to a cloud based server so that the user can look at all such statistics. Thus, the aforementioned statistics can help micro-controller **210** decide when to stop delivering power to such a user.

After does device meet delivery criteria? Step **414**, micro-controller **210** in base station **204** may determine if receiver **106** is within the optimal range from the closest transmitter **102**, such analysis may be carried out at device is in optimal range? Step **416**. If receiver **106** is within the optimal range,

then transmitter **102** may deliver power at deliver power Step **420**, if receiver **106** is out of the optimal range, then micro-controller **210** may use reflectors **302** and wireless repeaters **304** for increasing the optimal range, such operation may be performed at use range enhancers Step **418**. Subsequently, receiver **106** may receive charge at deliver power Step **420**.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments may be contemplated. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A method of authenticating and controlling wireless power delivery, comprising:

at a wireless power transmitter:

receiving, from an electronic device, a request for the transmission of power from the transmitter to a receiver associated with the electronic device;

obtaining, from the electronic device, an identifier of the electronic device and a power requirement;

determining a location of the receiver associated with the electronic device;

determining, based on at least the identifier, whether the electronic device is authorized to receive power;

upon determining that the electronic device is authorized to receive power:

generating power transmission waves to form a pocket of energy in response to the power requirement and the location of the receiver,

wherein an assigned priority is determined for the electronic device to receive power prior to generating the power transmission waves; and

transmitting the power transmission waves through at least two antennas coupled to the transmitter for receipt by the receiver to power the electronic device.

2. The method according to claim **1**, wherein the transmitting further comprises transmitting controlled power transmission waves that converge in 3-D space.

3. The method according to claim **1**, wherein communications between the transmitter and the electronic device are through a communication signal using a protocol selected from the group consisting of: Bluetooth®, Wi-Fi®, ZigBee®, or FM radio.

4. The method according to claim **1**, wherein the pocket of energy is regulated by utilizing adaptive pocket-forming.

5. The method according to claim **1**, wherein the antennas of the transmitter are one or more of flat antennas, patch antennas, dipole antennas, or combinations thereof.

6. The method according to claim **1**, wherein two or more antennas of the transmitter operate in independent frequencies configured to allow a multichannel operation of pocket-forming in a single array, pair array, quad array, or other suitable arrangement.

7. The method according to claim **1**, wherein the antennas of the transmitter are configured to polarize the power transmission signals to include vertical polarization, horizontal polarization, circular polarization, elliptical polarization, or combinations thereof.

8. The method according to claim **1**, wherein the power requirement is the charge level of the electronic device.

9. The method according to claim **1**, wherein the identifier includes an identification of the manufacturer of the electronic device.

10. The method according to claim **1**, wherein the identifier includes a serial number.

11. The method according to claim **1**, wherein determining whether the electronic device is authorized to receive power comprises:

receiving a password from the electronic device;

and verifying that the password matches a stored password authorized to receive power from the transmitter.

12. The method according to claim **1**, wherein determining whether the electronic device is authorized to receive power comprises determining an authorized amount of power and an authorized location for transmitting power based on at least the identifier.

13. The method according to claim **1**, further comprising, generating the power transmission waves based on the electronic device's assigned priority.

14. The method according to claim **13**, wherein the assigned priority is based on the power requirement of the electronic device.

15. The method according to claim **13**, wherein the assigned priority is based on preferences set by the user.

16. The method according to claim **1**, wherein the highest priority is assigned to devices selected from a group consisting of smoke detectors, digital door locks, and CCTV cameras.

17. The method according to claim **1**, wherein the transmitting further comprises controlling the generated power transmission waves to provide phase shifting and gain shifting with respect to other power transmission waves.

18. A transmitter for authenticating and controlling wireless power delivery, the transmitter comprising a processor that is coupled with a plurality of wireless power antenna and is configured to couple to a source of power, wherein the processor is configured to:

receive, from an electronic device, a request for the transmission of power from the transmitter to a receiver associated with the electronic device;

obtain, from the electronic device, an identifier of the electronic device and a power requirement;

determine a location of the receiver associated with the electronic device;

determine, based on at least the identifier, whether the electronic device is authorized to receive power;

upon determining that the electronic device is authorized to receive power:

generate power transmission waves to form a pocket of energy in response to the power requirement and the location of the receiver,

wherein an assigned priority is determined for the electronic device to receive power prior to generating the power transmission waves; and

transmit the power transmission waves through at least two antennas coupled to the transmitter for receipt by the receiver to power the electronic device.

19. A method of authenticating and controlling wireless power delivery, comprising:

at a wireless power transmitter:

receiving, from an electronic device, a request for the transmission of power from the transmitter to a receiver associated with the electronic device obtaining, from the electronic device, an identifier of the electronic device and a power requirement;

determining a location of the receiver associated with the electronic device;

determining, based on at least the identifier, whether the electronic device is authorized to receive power;

upon determining that the electronic device is authorized to receive power:

generating power transmission waves to form a pocket of energy in response to the power requirement and the location of the receiver; and

transmitting the power transmission waves through at least two antennas coupled to the transmitter for receipt by the receiver to power the electronic device,

wherein the transmitting further comprises controlling the generated power transmission waves to provide phase shifting and gain shifting with respect to other power transmission waves.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,090,699 B1
APPLICATION NO. : 14/586197
DATED : October 2, 2018
INVENTOR(S) : Leabman et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Claim 18, Column 8, Line 30, please delete "power antenna" and insert --power antennas--;

Claim 19, Column 8, Line 58, please delete "electronic device obtaining," and insert --electronic device; obtaining,--.

Signed and Sealed this
Fourth Day of December, 2018

Andrei Iancu
Director of the United States Patent and Trademark Office